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Minnesota's Forest Resources in 2001

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Minnesota's Forest Resources in 2001

The North Central Research Station's Forest Inventory and Analysis (NCFIA) program began fieldwork for the sixth forest inventory of Minnesota's forest resources in 1999. This inventory initiated the new annual inventory system in which one-fifth of the field plots (considered one panel) in the State are measured each year. A complete inventory consists of measuring and compiling the data for all plots (or five panels). Once all panels have been measured, each will be remeasured approximately every 5 years. For example, in Minnesota, the field plots measured in 1999 will be remeasured in 2004.

In 2001, NCFIA continued the annual inventory effort with the third panel of the sixth forest inventory. Reports of previous inventories of Minnesota are dated 1936, 1953, 1962, 1977, and 1990. This sixth inventory of Minnesota's forest resources will be completed in 2003. However, because each year's sample is a systematic sample of the State's forest and because timely information is needed about Minnesota's forest resources, estimates have been prepared from data gathered during the first 3 years of the inventory. Data presented in this report represent 60 percent of the field plots (or three panels) for a complete inventory and are a combination of the first year's panel from 1999, the second year's panel from 2000, and the third year's panel from 2001. Earlier reports for the 1999 panel (Schmidt 2000) and the combined 1999 and 2000 panels (Haugen *et al.* 2002) have also been published. Results presented are estimates based on sampling techniques; estimates were compiled assuming the 1999, 2000, and 2001 data represent one large sample. As additional annual inventories are completed in years 4 and 5, the precision of the estimates will increase and additional data will be released.

Data from new inventories are often compared with data from earlier inventories to determine trends in forest resources. However, for the comparisons to be valid, the procedures used in the two inventories must be similar. As a result of our ongoing efforts to improve the efficiency and reliability of the inventory, several changes in procedures and definitions have been made since the last Minnesota inventory in 1990 (Miles *et al.* 1995) (see appendix). While these changes will have little impact on statewide estimates of forest area, timber volume, and tree biomass, they may have significant impacts on plot classification variables such as forest type and stand-size class. Some of these changes make it inappropriate to directly compare 2001 data tables with those published for 1990.

RESULTS

Area

The total land area of Minnesota is 50.9 million acres of which 32 percent or 16.3 million acres are forest land. There are three components to forest land: (1) Timberland[1]—forest land that is not restricted from harvesting by statute, administrative regulation, or designation and is capable of growing trees at a rate of 20 cubic

[1] *Timberland may not be equivalent to the area actually available for commercial timber harvesting or other access. The actual availability of land for various uses depends upon owner decisions that consider economic, environment, and social factors.*

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feet per acre per year; (2) Reserved forest land—land that is restricted from harvesting by statute, administrative regulation, or designation (i.e., national parks, wilderness areas, etc.); and (3) Other forest land—low-productivity forest land that is not capable of growing trees at a rate of 20 cubic feet per acre per year.

The estimated area of forest land declined from 16.7 million acres in 1990 to 16.3 million acres in 2001. During the same period, timberland showed a slight increase from 14.7 million acres in 1990 to 15.0 million acres in 2001 (fig. 1)[2]. The decrease in forest land and the increase in timberland are due in large part to changes in the reserved and other forest land components. The estimate of reserved forest land decreased from 1,117 thousand acres in 1990 to 962 thousand acres in 2001, and the area estimate of other forest land decreased from 840 thousand acres to 349 thousand acres. Nearly half of this acreage decrease in reserved and other forest land was due to conversion to non-forest land with the other half due to conversion to timberland. The net effect was a decrease in the area estimate for forest land and an increase in the area estimate for timberland.

The estimate of timberland in public ownership increased from 7.584 million acres in 1990 to 8.064 million acres in 2001 while private ownership declined from 7.1392 million acres to 6.9185 million acres over the same period (fig. 2). Nearly four-fifths of all conifer forest types are found on publicly owned land. Over four-fifths of all private timberland is in the hardwood forest types.

Changes in the plot design, stocking, and forest typing algorithms limit comparisons of the 1990 and 2001 inventories. This is especially true with plot classification variables such as forest type and stand size. Whenever possible, comparisons should be based on observed variables such as tree species and diameter.

The aspen-birch forest type, with 6.7 million acres of timberland, is the dominant forest type in the State (fig. 3) and is an important resource for Minnesota's forest industries. Three-fourths of all the coniferous timberland in the State is in the spruce-fir forest type (3.1 million acres). Between inventories, the estimate of hardwood forest types increased from 10.2 million acres in

[2]*The error bars atop each bar in figure 1 provides a measure of reliability of these figures. In 2001 there was a two out of three chance that if a 100-percent inventory had been taken, using the same methods, the result would have been within the limits indicated by the bracket—14,982.5 thousand acres plus or minus 128.9 thousand acres.*

Figure 1.—*Area of timberland in Minnesota by inventory year.*

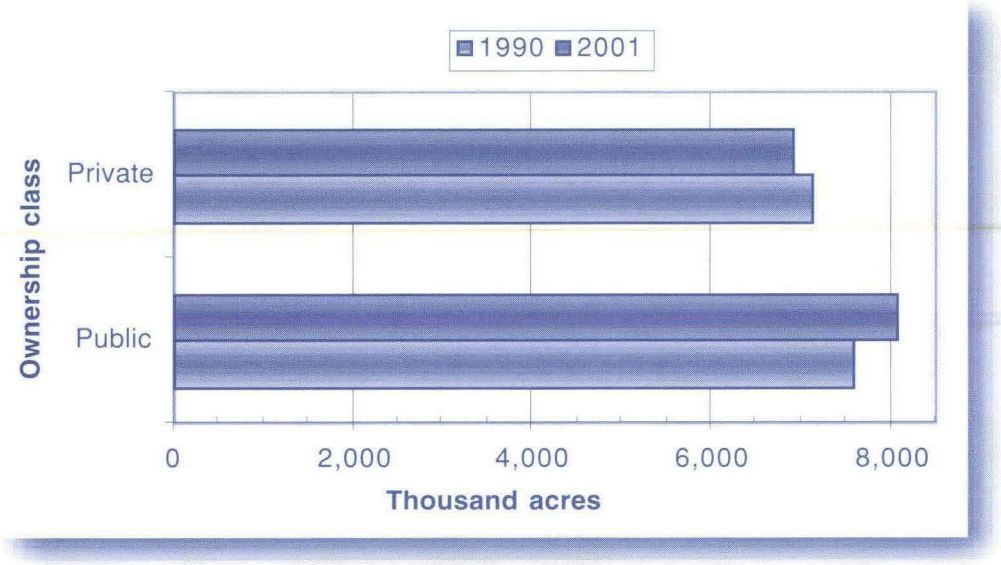


Figure 2.—*Area of timberland in Minnesota by owner category.*

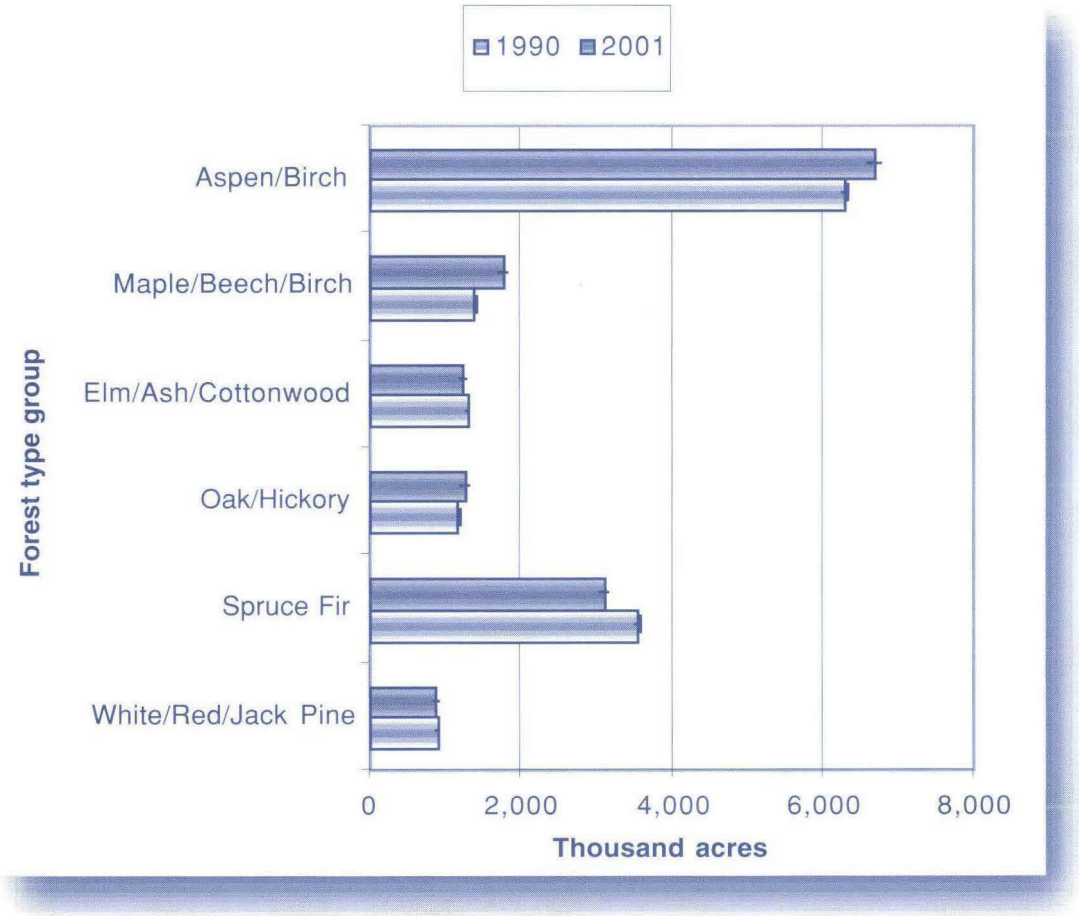


Figure 3.—*Area of timberland in Minnesota in 1990 and 2001 by forest type.*

1990 to 10.9 million acres in 2001, while the estimate for conifer forest types decreased from 4.4 million acres in 1990 to 4.0 million acres in 2001. This appears to be the result of new stocking and forest typing algorithms used in conjunction with a new plot design rather than a change in species composition because roughly 31 percent of the State's growing-stock volume was in softwood tree species in both 1990 and 2001.

The area classified as small-diameter stands (sapling/seedling stands where a plurality of the stocking is in trees less than 5.0 inches at diameter breast height (d.b.h.)) increased by 16 percent or by 701 thousand acres from 1990 (4,444.2 thousand acres) to 2001 (5,144.8 thousand acres). Most of this increase occurred in the aspen-birch forest type where the area of sapling/seedling stands is estimated to have increased by 692 thousand acres. These changes in area by stand-size class are due in part to changes in the plot design and changes in the stand-size classification algorithm (see Inventory Methods in the appendix).

The area classified as medium stands (poletimber stands where a plurality of the stocking is in trees from 5 to 9 inches d.b.h. for conifers and 5 to 11 inches d.b.h. for hardwoods), rose from 5.3 million acres of timberland in 1990 to 5.7 million acres in 2001, despite an 8-percent decline in the number of poletimber-size trees. Over the same period the area classified as large stands (sawtimber stands where a plurality of the stocking is in trees at least 9.0 inches d.b.h. for conifers or 11.0 inches d.b.h. for deciduous trees) decreased by 17 percent (819 thousand acres) from 1990 (4,890.3 thousand acres) to 2001 (4,072.9 thousand acres), despite a 2-percent increase in the number of sawtimber trees. Three-fifths of this decrease occurred in the aspen-birch type.

Volume

Historically, volume has been reported as either growing stock or sawtimber. However, there are volumes in noncommercial trees, rough trees, and rotten trees that do not qualify as growing stock but that are utilized for wood fiber and fuelwood. Such trees also make important ecological contributions (such as for wildlife habitat, and soil and water protection). With the annualized inventory system and increased interest in FIA data from an ecological perspective, a greater focus has been placed on all live volume. In 2001, Minnesota had 17.4 billion cubic feet of all live volume on its 16.3 million acres of forest land. This equates to an average of 1,068 cubic feet of all live volume for each forest land acre in Minnesota. Unfortunately, all live volume is not readily available from the historic inventories and thus comparisons over time consider only growing-stock volume.

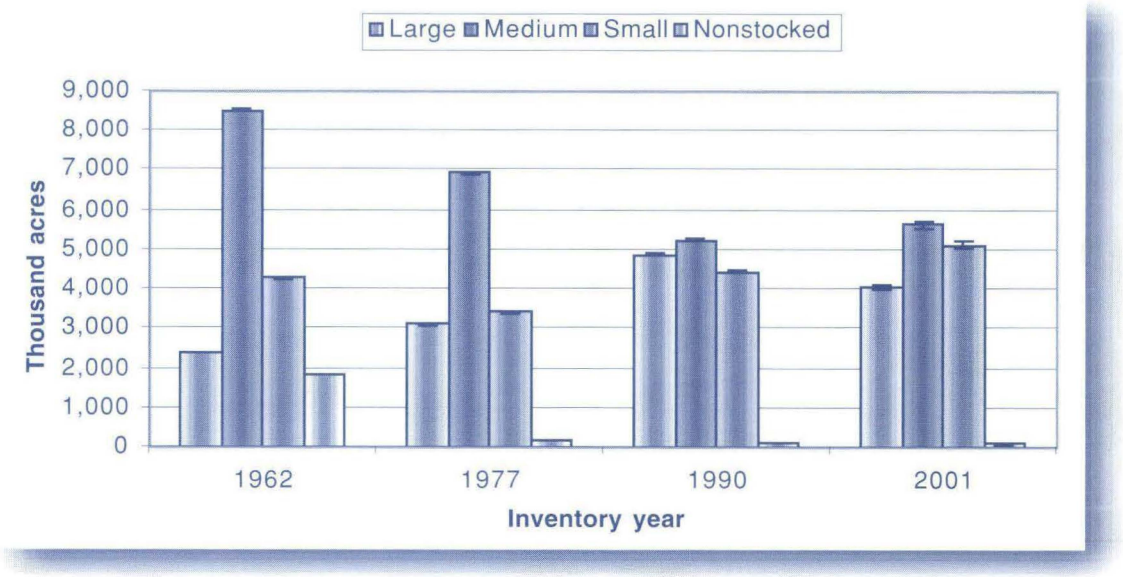


Figure 4.—*Area of timberland in Minnesota by stand-size class and inventory year.*

The net volume of growing stock on timberland in Minnesota was estimated at 14.9 billion cubic feet on 15.0 million acres in 2001, or 998 cubic feet of growing stock per acre (fig. 5). The 1990 inventory estimates were 15.1 billion cubic feet of growing stock on 14.7 million acres of timberland, or 1,028 cubic feet of growing stock per acre.

The growing-stock volume of poletimber-size trees decreased from 7.8 billion cubic feet in 1990 to 7.0 billion cubic feet in 2001, while the growing-stock volume of sawtimber-size trees increased from 7.4 billion cubic feet in 1990 to 8.0 billion cubic feet in 2001.

Hardwoods make up 69 percent of the growing-stock volume and 65 percent of the sawtimber volume in the State (fig. 6). In 2001, the cottonwood-aspen species group accounted for 39 percent of the hardwood volume, followed by other eastern soft hardwoods (15 percent), ash (10 percent), basswood (8 percent), select white oaks (7 percent), select red oaks (7 percent), soft maple (6 percent), and hard maple (5 percent).

Softwood growing-stock volume was estimated at 4.6 billion cubic feet in 2001. The spruce and balsam fir species group accounted for 37 percent of the softwood volume, followed by other eastern softwoods (31 percent), eastern white and red pines (22 percent), and jack pine (10 percent).

Biomass

Biomass, measured as all live aboveground tree biomass on timberlands, was estimated at 429 million dry tons in 2001 (an average of 29 dry tons per acre). Biomass estimates are increasing in importance for analyses on carbon sequestration, wood fiber availability for fuel, and other issues. In 2001, 77 percent of the total biomass was in growing-stock trees, an additional 14 percent was in trees less than 5 inches d.b.h., and the remaining 9 percent was in non-growing-stock trees. Three-quarters of the total biomass was composed of hardwood species. Although total biomass was almost evenly split on private (213 million dry tons) and public (217 million dry tons) timberlands, softwoods made up 34 percent of the total biomass on public lands, but only 14 percent on private lands.

Forest Health

Staff of the Northeastern Area State and Private Forestry Health Protection program, St. Paul Field Office, provided the following forest health information.

Insects, pathogens, weather events, fire, and other factors cause damage and losses on forests throughout Minnesota every year. Since 1954, the eastern spruce budworm (*Choristoneura fumiferana*) has defoliated spruce/fir forests annually, establishing itself as the most consistently damaging agent in the State. However,

Figure 5.—*Growing-stock volume in Minnesota by inventory year.*

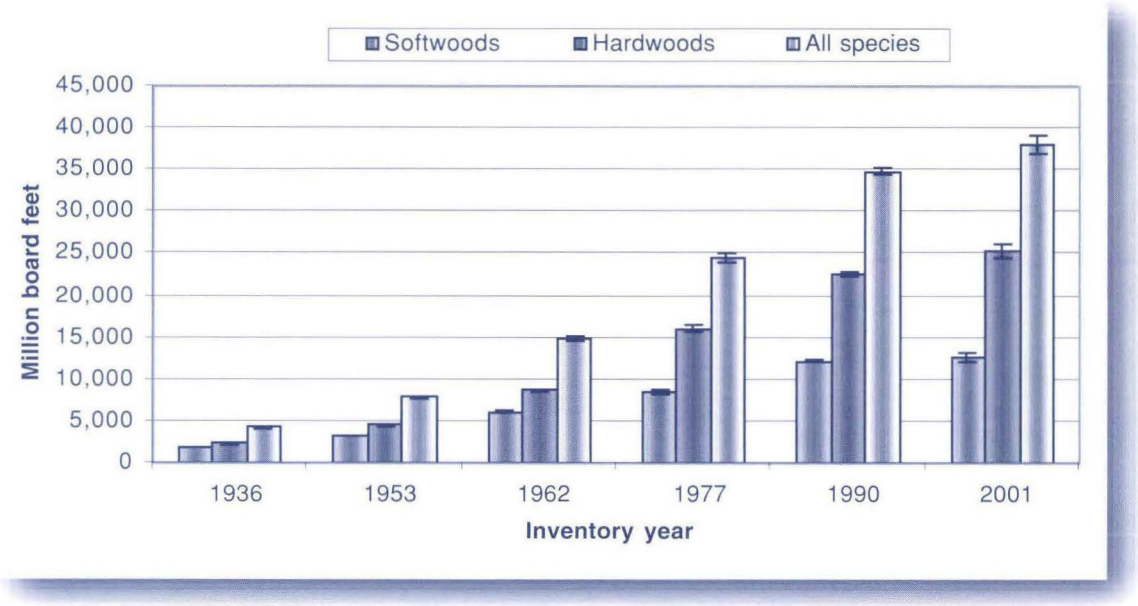


Figure 6.—*Sawtimber volume in Minnesota by inventory year.*

since 1994, spruce budworm has been declining steadily (fig. 7). But as the budworm has declined over that period, other damage agents have stepped up their activity. Most notably the forest tent caterpillar (*Malacosoma disstria*) has been active throughout aspen and birch forests, defoliating over 7.7 million acres in 2001 (table 10). Populations are expected to continue to be at damaging levels in 2002. Other significant damage agents that have been active during the period between inventories are the large aspen tortrix (*Choristoneura conflictana*) affecting the aspen and birch forest types; the jack pine budworm (*Choristoneura pinus*) defoliating and killing older, open growing jack pine; and the introduced larch casebearer (*Coleophora laricella*), which has been increasing recently, defoliating larch (table 10).

Since 1996, all of these and other defoliating agents have been active, sometimes on some of the same acreages at the same time. Trees that are repeatedly defoliated often sustain measurable growth loss, which, in turn, sometimes results in mortality. Figure 7 shows areas of the State where, since 1997, forested lands have been defoliated between one and five times.

Arguably, agents completely beyond human control, namely the weather, cause the most significant damage. Periods of drought and flooding, snow, ice, cold, and wind damage are an integral component of the State's forest dynamics. The single most significant event occurred in 1999 when about 465,000 acres of northern forests were blown down by straight-line winds (fig. 8). This caused varying degrees of breakage and mortality, which, in turn, has had longer term impacts on subsequent insect and pathogen activity and fire. The annual current mortality resulting from all of these damage agents, exceeding 10 percent of standing trees, is displayed in figure 9. A more complete discussion of forest health issues that have affected Minnesota forests since the last complete forest inventory, and current events is available at: http://www.na.fs.fed.us/spfo/fhm/fhh/fhh-01/mn/mn_01.htm.

For Further Information

Additional data related to the three most recent inventories of Minnesota (1977, 1990, 2001) are available at: http://www.ncrs.fs.fed.us/4801/fiadb/index.htm.

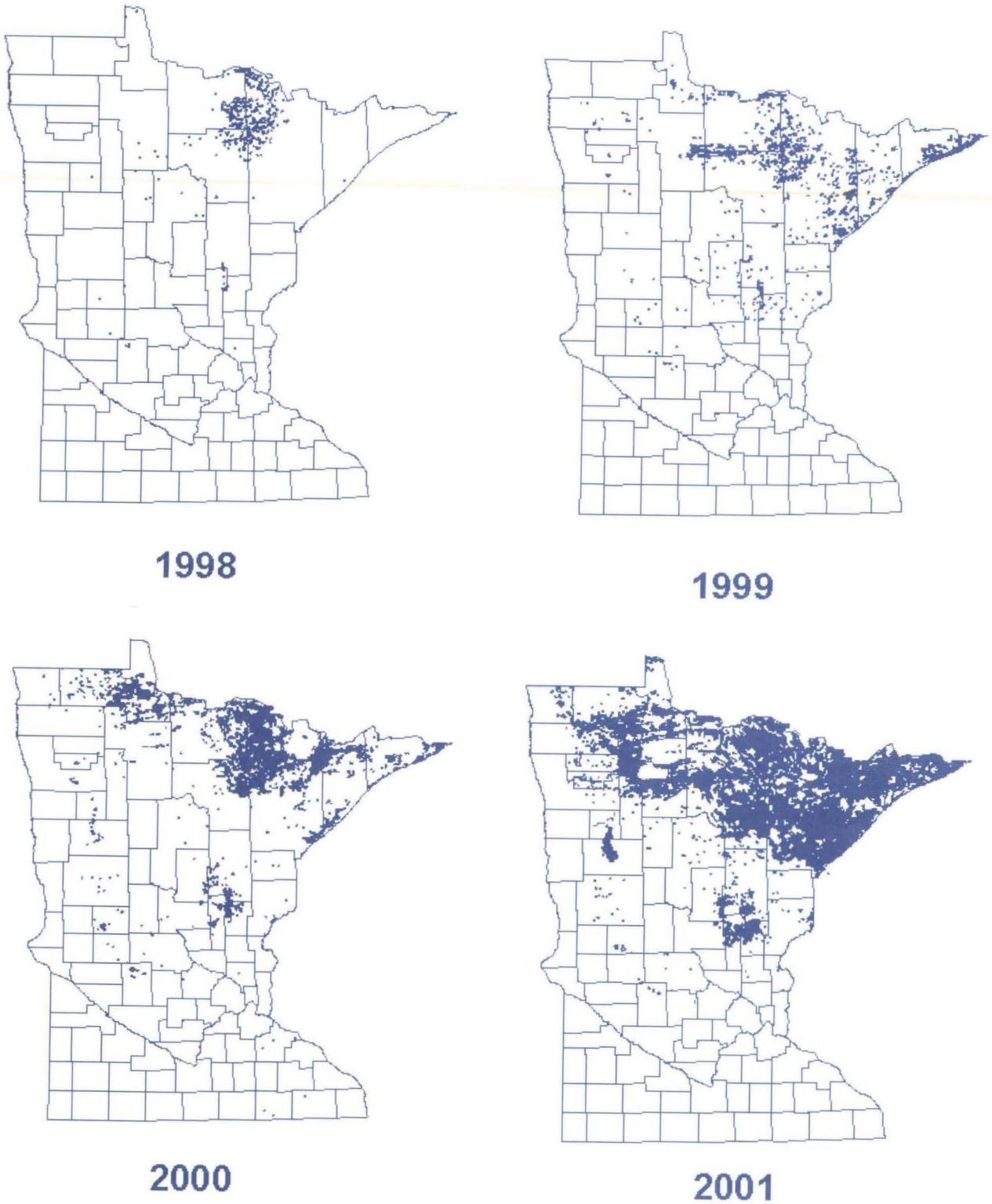


Figure 7.—*Areas of damage mapped by aerial survey, 1998-2001 (Forest Health Protection, St. Paul Field Office).*

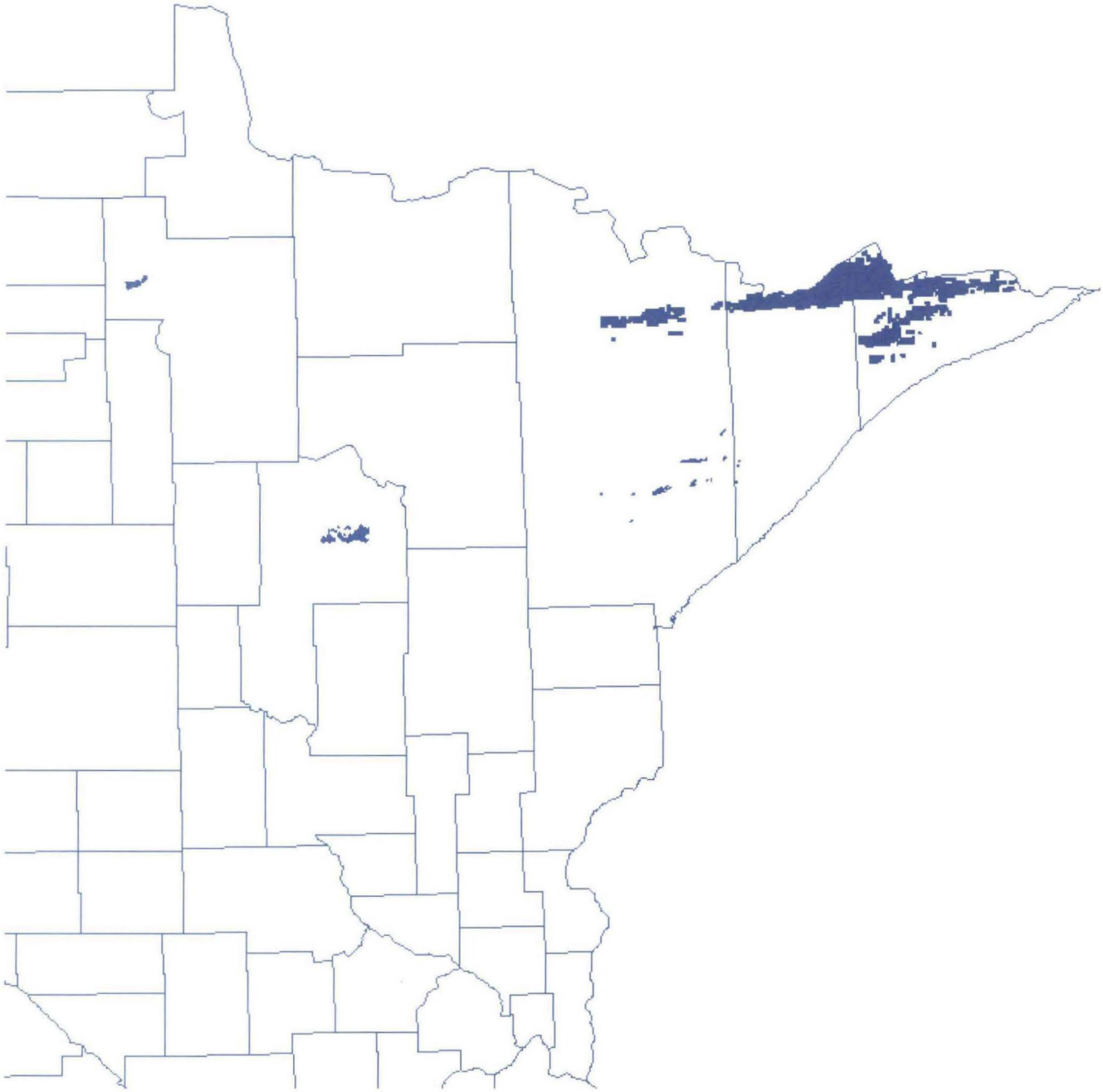
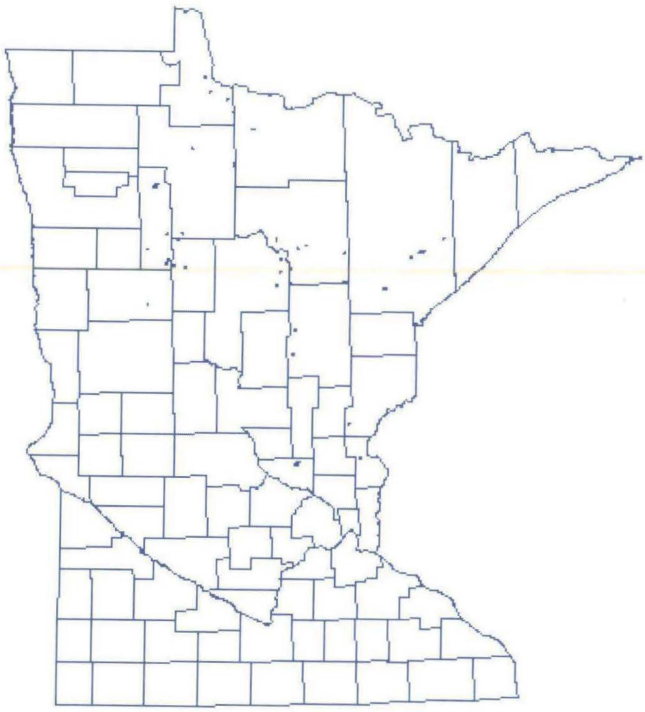
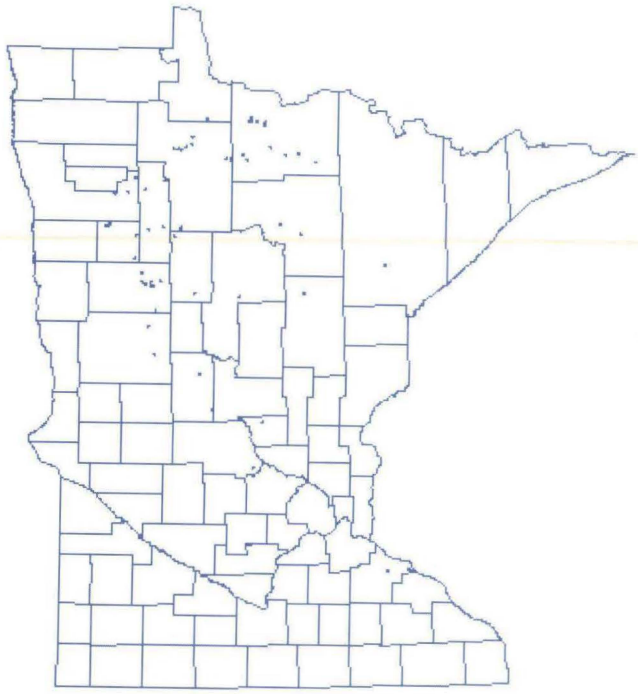


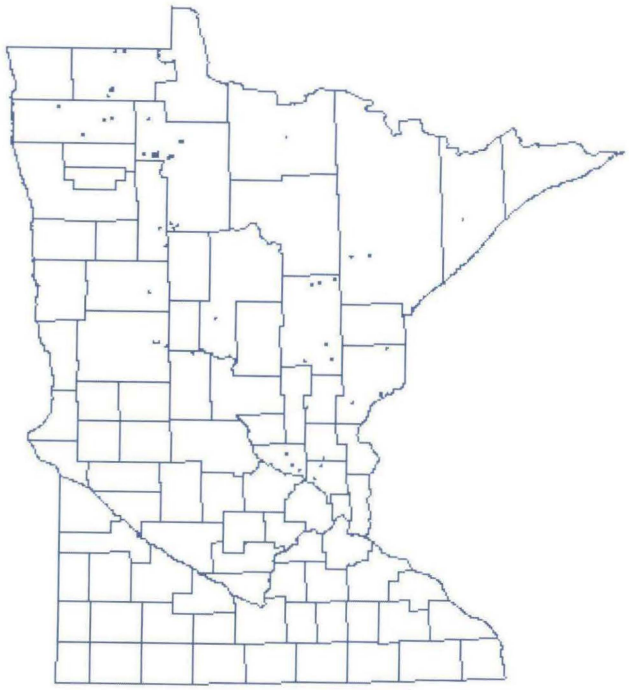
Figure 8.—*Storm damage resulting from straight-line winds on July 4, 1999, includes mortality, broken, up-rooted and still alive (Forest Health Protection, St. Paul Field Office).*



1998



1999



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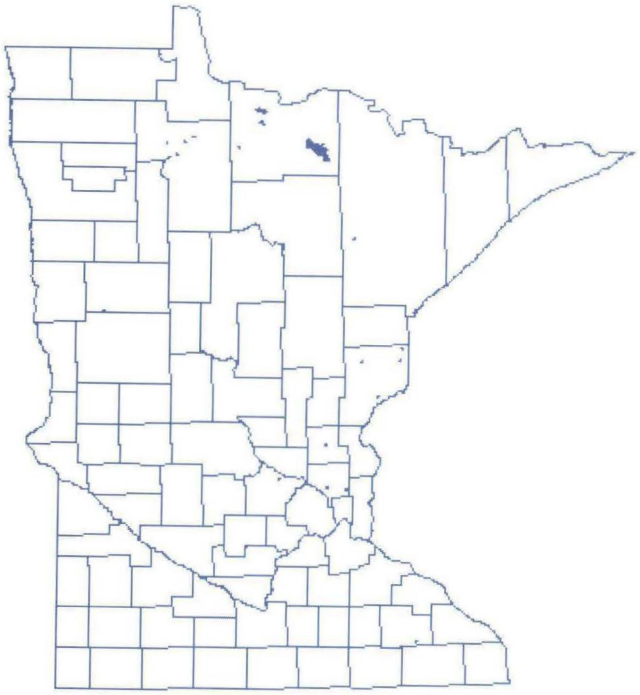

2001

Figure 9.—*Areas of >10 percent mortality mapped by aerial survey, 1998-2001 (Forest Health Protection, St. Paul Field Office) (1999 storm damage in northeast Minnesota was not included - see figure 8).*

APPENDIX

Inventory Methods

Since the 1990 inventory of Minnesota, several changes have been made in NCFIA inventory methods to improve the quality of the inventory as well as meet increasing demands for timely forest resource information. The most significant change between inventories has been the change from periodic inventories to annual inventories. Historically, NCFIA periodically inventoried each State on a cycle that averaged about 13 years for recent inventories. However, the need for timely and consistent data across large geographical regions, combined with national legislative mandates, resulted in NCFIA's implementation of an annual inventory system. Minnesota was one of the first States in the North Central region, and one of the first States in the Nation, to be inventoried with this new system, beginning with the 1999 panel of measurements.

With an annual inventory system, about one-fifth of all field plots are measured in any one year. After 5 years, an entire inventory cycle will be completed. After the first 5 years, NCFIA will report and analyze results as a moving 5-year average. For example, NCFIA will be able to generate a report based on inventory results for 1999 through 2003 or for 2000 through 2004. While there are great advantages for an annual inventory, one difficulty is reporting on results in the first 4 years. With the 2001 annual measurements, only 60 percent of all field plots have been measured. Sampling error estimates for the 2001 inventory results are area of forest land 0.86 percent, area of timberland 0.97 percent, number of growing-stock trees on timberland 2.09 percent, volume of growing stock on timberland 1.93 percent, and volume of sawtimber on timberland 2.76 percent. These sampling error estimates are considerably higher than those for the last periodic inventory completed in 1990 (i.e., 0.36 percent for timberland area and 0.71 percent for growing-stock volume) because of the smaller sample sizes. Thus, caution should be used when drawing conclusions based on this limited data set. As we complete ensuing measurements, we will have additional confidence in our results due to the increased number of field plots measured. As each measurement year is completed, the precision of estimates will improve.

Other significant changes between inventories include the implementation of new remote sensing technology, the implementation of a new field plot design, and the gathering of additional remotely sensed and field data. The advent of remote sensing technology since the previous inventory in 1990 has allowed NCFIA to use computer-assisted classifications of Multi-Resolution Land Characterization (MRLC) data and other available remote sensing products to stratify the total area of the State and to improve estimates. Previous inventories in Minnesota (1936, 1953, 1962, 1977, and 1990) used manual interpretation of aerial photos to stratify the sample.

New algorithms were used in 1999-2001 to assign forest type and stand-size class to each condition observed on a plot. These algorithms are being used nationwide by FIA to provide consistency among States and will be used to reassign the forest type and stand-size class of every plot measured in the 1990 inventory when it is updated. This will be done so that changes in forest type and stand-size class will more accurately reflect actual changes in the forest and not changes in how values are computed. The list of recognized forest types, grouping of these forest types for reporting purposes, equations used to assign stocking values to individual trees, definition of nonstocked, and names given to the forest types changed with the new algorithms. As a result,

comparisons between the published 1999-2001 measurement results and those published for the 1990 inventory results may not be valid. For additional details regarding algorithms used in both inventories, please contact NCFIA.

Sampling Phases

The 2001 Minnesota survey used a two-phase sample for stratification that included remeasuring inventory plots from the 1990 inventory and measuring new field plots. Two-phase sampling, also called double sampling, consists of a phase 1 sample to estimate area by strata and a phase 2 sample to estimate the average value of parameters of interest within these strata. The estimated population total for a parameter is the sum across all strata of the product of each stratum's estimated area and the parameter's estimated mean per unit area.

The only land that could not be sampled was private land where field personnel could not obtain permission from the owner to measure the field plot and plots that could not be accessed because of a hazard or danger to field personnel. The methods used in the preparation of this report make the necessary adjustments to account for sites where access was denied or hazardous. Fortunately, there were only 23 denied access or hazardous plots in 1999, 60 in 2000, and 70 in 2001.

Phase 1

In this first phase the Minnesota inventory used a computer-assisted classification of satellite imagery. FIA used the imagery to form two initial strata—forest and nonforest. Pixels within 60 m (2 pixel widths) of a forest-nonforest boundary formed two additional strata—forest-edge and nonforest-edge. Forest pixels within 60 m on the forest side of a forest-nonforest boundary were classified into forest-edge strata. Pixels within 60 m of the boundary on the nonforest side were classified into nonforest-edge strata. An overlay of all national forest land was used to identify all lands owned by national forests. These national forest lands were treated separately but were also put into one of the above four strata. Stratification and estimation were conducted at the State level for national forest lands and at the FIA Inventory Unit level for other lands. In the national forest stratum, forest and forest-edge strata were combined.

Phase 2

Phase 2 of the inventory consisted of the measurement of the annual sample of field plots in Minnesota. Current FIA precision standards for annual inventories require a sampling intensity of one plot for approximately every 6,000 acres. FIA has established a grid that divides the entire area of the United States into non-overlapping hexagons, each of which contains approximately 5,937 acres (McRoberts 1999). A grid of field plots was established by selecting one plot from each hexagon based on the following rules: (1) if a Forest Health Monitoring (FHM) plot (Mangold 1998) fell within a hexagon, it was selected as the grid plot; (2) if no FHM plot fell within a hexagon, the existing NCFIA plot from the 1990 inventory nearest the hexagon center was selected as the grid plot; and (3) if neither FHM nor existing NCFIA plots fell within the hexagon, a new NCFIA plot was established in the hexagon (McRoberts 1999). This grid of plots is designated the Federal base sample and is considered an equal probability sample; its measurement in Minnesota is funded by the Federal government.

The total Federal base sample was systematically divided into five interpenetrating, non-overlapping subsamples or panels. Each year the plots in a single panel are measured, and panels are selected on a 5-year, rotating basis (McRoberts 1999). For estimation purposes, the measurement of each panel of plots may be considered an independent systematic sample of all land in a State. Field crews measure vegetation on plots forested at the time of the last inventory and on plots currently classified as forest by trained photointerpreters using aerial photos or digital ortho-quads.

NCFIA has two categories of field plot measurements—phase 2 field plots and phase 3 plots (FHM plots)—to optimize our ability to collect data when available for measurement. Both types of plot are systematically distributed both geographically and temporally. Phase 3 plots are measured with the full suite of FHM vegetative and health variables collected as well as the full suite of measures associated with phase 2 plots. Phase 3 plots must be measured between June 1 and August 30 to accommodate the additional measurement of non-woody understory vegetation, ground cover, soils, and other variables. We anticipate that in Minnesota the complete 5-year annual inventory will involve about 465 phase 3 plots. On the remaining plots, referred to as phase 2 plots, only variables that can be measured throughout the entire year are collected. In Minnesota, the complete 5-year annual inventory is expected to involve about 5,200 phase 2 forested plots. The 1999-2001 annual inventory results represent field measures on 2,672 timberland, 217 other forest land, and 6,179 non-forest land plots. The above number of field plots represents a single intensification for the standard base Federal sample in 1999 and a double intensification for 2000 and 2001. This double intensification was made possible by additional resources provided by the State of Minnesota.

The new national FIA 4-point cluster plot design (fig. 10) was first used for data collection during the 1999 measurement of Minnesota. This design was also used in the 2000 and 2001 measurements and will be used in subsequent years. The national plot design requires mapping forest conditions on each plot. Due to the small sample size (20 percent) each year, precision associated with change factors such as mortality will be relatively low. Consequently, change estimates were not reported in the 1999 or 2000 reports. Estimates of change are reported for 2001 but are limited in detail. When all five annual panels are completed in 2004, the full range of change data will be available.

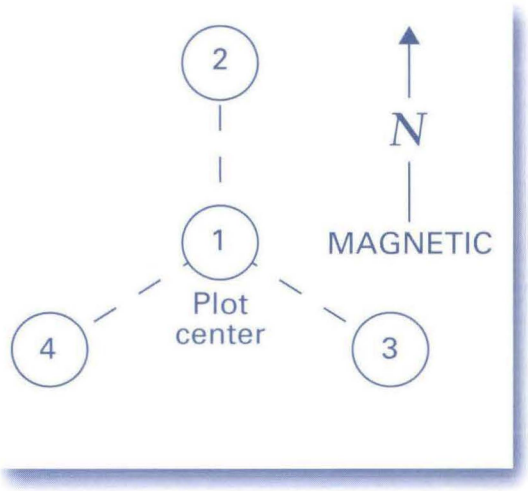

Figure 10.—*Current NCFIA field plot design.*

The overall plot layout for the new design consists of four subplots. The centers of subplots 2, 3, and 4 are located 120 feet from the center of subplot 1. The azimuths to subplots 2, 3, and 4 are 0, 120, and 240 degrees, respectively. The center of the new plot is located at the same point as the center of the previous plot if a previous plot existed within the sample unit. Trees with a d.b.h. of 5 inches and larger are measured on a 24-foot-radius (1/24 acre) circular subplot. All trees less than 5 inches d.b.h. are measured on a 6.8-foot-radius (1/300 acre) circular microplot located 12 feet east of the center of each of the four subplots. Forest conditions that occur on any of the four subplots are recorded. Factors that differentiate forest conditions are changes in forest type, stand-size class, land use, ownership, and density. Each condition that occurs anywhere on any of the subplots is identified, described, and mapped if the area of the condition meets or exceeds 1 acre in size and 120 feet in width. Field plot measurements are combined with phase 1 estimates in the compilation process and table production. The number of tables generated from less than five panels of data is limited. However, as additional annual inventories are completed, the number of tables will increase until year 5, when all statewide

inventory summary tables will be available in both printed and electronic formats. For additional information, contact:

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TABLE TITLES

Table 1.—*Area of forest land by forest type group and owner category, Minnesota, 1999-2001*

Table 2.—*Area of timberland by major forest type group, stand origin, and owner category, Minnesota, 1999-2001*

Table 3.—*Area of timberland by forest type group and stand-size class, Minnesota, 1999-2001*

Table 4.—*Net volume of all live trees on forest land by species group and owner category, Minnesota, 1999-2001*

Table 5.—*Net volume of all live trees and salvable dead trees on timberland by class of timber and softwood/hardwood categories, Minnesota, 1999-2001*

Table 6.—*Net volume of growing stock on timberland by forest group and softwood/hardwood species categories, Minnesota, 1999-2001*

Table 7.—*Net volume of growing stock on timberland by species group and diameter class, Minnesota, 1999-2001*

Table 8.—*Net volume of sawtimber on timberland by species group and diameter class, Minnesota, 1999-2001*

Table 9.—*All live aboveground tree biomass on timberland by owner category, softwood/hardwood species category, and tree biomass component, Minnesota, 1999-2001*

Table 10.—*Area of forest land in Minnesota affected by damage agents, 1994-2001*

TABLES

Table 1. -- Area of forest land by forest type group and owner category, Minnesota, 1999 - 2001

(In thousand acres)

Forest type group	Owner category			
	All owners	Public	Private	Unidentified owner
Softwood type groups				
White / red / jack pine group	1,042.9	723.1	319.8	--
Spruce / fir group	3,618.9	2,865.2	753.7	--
Exotic softwood group	3.9	--	3.9	--
All softwood types	4,665.7	3,588.2	1,077.5	--
Hardwood type groups				
Oak / pine group	7.1	--	7.1	--
Oak / hickory group	1,274.6	309.8	964.8	--
Elm / ash / cottonwood group	1,283.3	515.2	768.2	--
Maple / beech / birch group	1,818.3	673.3	1,145.0	--
Aspen / birch group	7,130.3	4,102.0	3,028.3	--
All hardwood types	11,513.6	5,600.3	5,913.3	--
Nonstocked	114.4	75.8	38.7	--
All forest types	16,293.7	9,264.3	7,029.4	--

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their total due to rounding.

Table 2. -- Area of timberland by major forest type group, stand origin, and owner category, Minnesota, 1999 - 2001

(In thousand acres)

Major forest type group and stand origin	Owner category			
	All owners	Public	Private	Unidentified owner
Softwood type groups				
Natural	3,491.3	2,661.1	830.2	--
Planted	481.6	303.5	178.1	--
All softwood types	3,972.9	2,964.6	1,008.3	--
Hardwood type groups				
Natural	10,708.1	4,944.0	5,764.2	--
Planted	200.2	88.6	111.6	--
All hardwood types	10,908.3	5,032.5	5,875.8	--
Nonstocked	101.2	66.9	34.3	--
All groups	14,982.5	8,064.0	6,918.5	--

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their totals due to rounding.

Table 3. -- Area of timberland by forest type group and stand-size class, Minnesota, 1999 - 2001

(In thousand acres)

Forest type group	All stands	Stand-size class			
		Sawtimber	Poletimber	Sapling-seedling	Non-stocked
Softwood type groups					
White / red / jack pine group	871.2	375.4	318.5	177.2	--
Spruce / fir group	3,097.8	427.6	1,013.8	1,656.4	--
Exotic softwood group	3.9	2.4	--	1.5	--
All softwood types	3,972.9	805.4	1,332.4	1,835.1	--
Hardwood type groups					
Oak / pine group	7.1	--	7.1	--	--
Oak / hickory group	1,245.0	753.6	378.6	112.8	--
Elm / ash / cottonwood group	1,218.0	324.8	587.0	306.2	--
Maple / beech / birch group	1,758.9	864.1	677.9	216.9	--
Aspen / birch group	6,679.3	1,324.9	2,680.6	2,673.8	--
All hardwood types	10,908.3	3,267.5	4,331.3	3,309.6	--
Nonstocked	101.2	--	--	--	101.2
All forest types	14,982.5	4,072.9	5,663.6	5,144.8	101.2

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their totals due to rounding.

Table 4. -- Net volume of all live trees on forest land by species group and owner category, Minnesota, 1999 - 2001

(In thousand cubic feet)

Species group	Owner category			
	All owners	Public	Private	Unidentified owner
Softwoods				
Other yellow pines	5,503	--	5,503	--
Eastern white and red pines	1,241,819	885,257	356,562	--
Jack pine	571,588	406,089	165,499	--
Spruce and balsam fir	1,912,428	1,393,190	519,237	--
Other eastern softwoods	1,589,143	1,181,339	407,805	--
Total softwoods	5,320,481	3,865,875	1,454,606	--
Hardwoods				
Select white oaks	934,370	190,386	743,984	--
Select red oaks	839,989	270,726	569,263	--
Other red oaks	97,798	4,109	93,688	--
Hickory	30,956	922	30,034	--
Yellow birch	61,191	47,632	13,559	--
Hard maple	670,951	352,056	318,896	--
Soft maple	782,478	364,391	418,087	--
Beech	--	--	--	--
Ash	1,138,608	452,707	685,901	--
Cottonwood and aspen	4,612,878	2,608,520	2,004,359	--
Basswood	948,233	304,794	643,439	--
Black walnut	36,907	292	36,615	--
Other eastern soft hardwoods	1,871,829	1,048,615	823,214	--
Other eastern hard hardwoods	9,992	696	9,296	--
Eastern noncommercial hardwoods	40,771	8,582	32,189	--
Total hardwoods	12,076,952	5,654,430	6,422,522	--
All species groups	17,397,433	9,520,304	7,877,128	--

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates that the volume rounds to less than 1 thousand cubic feet. Columns and rows may not add to their totals due to rounding.

Table 5. -- Net volume of all live trees and salvable dead trees on timberland by class of timber and softwood/hardwood categories, Minnesota, 1999 - 2001

(In thousand cubic feet)

Class of timber	All species	Softwood species	Hardwood species
Live trees			
Growing-stock trees			
Sawtimber			
Saw log portion	6,192,555	2,235,341	3,957,214
Upper stem portion	1,778,914	309,409	1,469,505
Total	7,971,469	2,544,750	5,426,719
Poletimber	6,975,337	2,069,808	4,905,529
All growing-stock trees	14,946,806	4,614,558	10,332,247
Cull trees			
Rough trees [1]			
Sawtimber size	752,488	64,076	688,413
Poletimber size	257,068	31,033	226,035
Total	1,009,556	95,109	914,447
Rotten trees [1]			
Sawtimber size	162,278	22,166	140,112
Poletimber size	33,558	4,175	29,383
Total	195,836	26,341	169,496
All live cull trees	1,205,392	121,449	1,083,943
All live trees	16,152,198	4,736,007	11,416,191
Salvable dead trees			
Sawtimber size	159,492	57,179	102,313
Poletimber size	162,696	64,952	97,744
All salvable dead trees	322,189	122,131	200,058
All classes	16,474,387	4,858,139	11,616,248

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates that the volume rounds to less than 1 thousand cubic feet. Columns and rows may not add to their totals due to rounding.

1 Includes noncommercial species.

Table 6. -- Net volume of growing stock on timberland by forest group and softwood/hardwood species categories, Minnesota, 1999 - 2001

(In thousand cubic feet)

Forest type group	All species	Softwood species	Hardwood species
Softwood type groups			
White / red / jack pine group	1,244,752	1,127,126	117,626
Spruce / fir group	2,341,322	2,131,147	210,175
Exotic softwood group	4,212	4,097	115
All softwood types	3,590,287	3,262,370	327,917
Hardwood type groups			
Oak / pine group	--	--	--
Oak / hickory group	1,619,917	53,855	1,566,062
Elm / ash / cottonwood group	1,420,449	145,949	1,274,499
Maple / beech / birch group	2,344,409	153,268	2,191,141
Aspen / birch group	5,961,697	992,209	4,969,489
All hardwood types	11,346,471	1,345,281	10,001,190
Nonstocked	10,048	6,908	3,140
All forest types	14,946,806	4,614,558	10,332,247

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates that the volume rounds to less than 1 thousand cubic feet. Columns and rows may not add to their totals due to rounding.

Table 7. -- Net volume of growing stock on timberland by species group and diameter class, Minnesota, 1999 - 2001

(In thousand cubic feet)

Species group	All classes	Diameter class (inches at breast height)									
		5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods											
Other yellow pines	4,316	218	986	1,707	1,404	--	--	--	--	--	--
Eastern white and red pines	1,018,046	83,636	129,576	137,526	93,838	83,657	88,997	102,856	95,411	168,791	33,759
Jack pine	454,230	53,810	102,960	128,266	79,775	51,637	19,649	12,662	5,472	--	--
Spruce and balsam fir	1,711,936	588,218	499,840	316,372	160,790	73,029	38,481	17,112	6,708	11,384	--
Other eastern softwoods	1,426,031	275,711	334,852	285,487	195,106	146,181	70,824	58,046	19,996	39,828	--
Total softwoods	4,614,558	1,001,594	1,068,215	869,358	530,912	354,504	217,951	190,675	127,587	220,004	33,759
Hardwoods											
Select white oaks	773,519	55,147	79,380	100,128	102,084	73,266	92,765	69,166	39,153	119,714	42,718
Select red oaks	756,812	21,262	54,080	90,557	132,494	138,234	91,914	72,841	77,995	60,253	17,182
Other red oaks	67,727	1,882	4,394	3,833	9,996	8,539	11,585	12,039	3,675	11,783	--
Hickory	30,593	3,436	4,825	5,921	9,059	5,226	2,127	--	--	--	--
Yellow birch	48,379	5,035	4,888	4,595	3,704	6,150	4,709	7,272	5,035	6,990	--
Hard maple	542,237	80,792	108,700	105,381	75,006	49,128	43,255	30,790	9,723	39,462	--
Soft maple	623,456	109,998	131,728	96,011	77,695	38,660	29,912	20,420	14,784	61,534	42,715
Beech	--	--	--	--	--	--	--	--	--	--	--
Ash	1,054,994	175,673	247,823	213,579	144,193	105,562	73,543	31,276	28,704	29,111	5,530
Cottonwood and aspen	3,997,937	476,894	656,144	719,535	695,443	586,873	404,824	188,394	86,538	147,285	36,008
Basswood	852,044	60,439	107,012	134,520	114,632	119,004	98,538	77,255	73,574	46,368	20,702
Black walnut	36,545	987	2,147	6,763	6,041	2,808	10,885	2,072	--	4,841	--
Other eastern soft hardwoods	1,538,267	255,540	401,882	367,520	257,491	126,100	81,068	17,141	11,259	20,267	--
Other eastern hard hardwoods	9,737	2,476	3,411	1,209	--	926	1,713	--	--	--	--
Total hardwoods	10,332,247	1,249,561	1,806,415	1,849,552	1,627,838	1,260,474	946,839	528,666	350,438	547,609	164,854
All species	14,946,806	2,251,155	2,874,630	2,718,911	2,158,750	1,614,978	1,164,790	719,342	478,025	767,613	198,613

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates that the volume rounds to less than 1 thousand cubic feet. Columns and rows may not add to their totals due to rounding.

Table 8. -- Net volume of sawtimber on timberland by species group and diameter class, Minnesota, 1999 - 2001

(In thousand board feet)[1]

Species group	All classes	Diameter class (inches at breast height)							
		9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods									
Other yellow pines	15,039	8,176	6,863	--	--	--	--	--	--
Eastern white and red pines	4,341,164	682,841	471,085	431,368	474,114	562,855	537,628	978,280	202,993
Jack pine	1,473,284	611,214	392,035	264,658	104,952	69,490	30,934	--	--
Spruce and balsam fir	3,212,374	1,585,904	824,988	386,424	211,040	97,346	38,727	67,946	--
Other eastern softwoods	4,250,889	1,440,741	1,000,587	766,336	380,648	319,558	112,718	230,300	--
Total softwoods	13,292,750	4,328,877	2,695,558	1,848,786	1,170,754	1,049,249	720,007	1,276,526	202,993
Hardwoods									
Select white oaks	2,506,213	--	418,492	320,117	422,993	325,960	189,300	602,045	227,307
Select red oaks	2,694,420	--	542,340	605,664	421,816	344,663	381,096	306,546	92,295
Other red oaks	267,887	--	41,782	37,946	53,242	57,323	18,228	59,366	--
Hickory	65,190	--	34,388	21,553	9,249	--	--	--	--
Yellow birch	168,470	--	16,579	29,135	23,040	36,863	26,022	36,831	--
Hard maple	1,137,821	--	314,819	220,514	203,604	149,262	48,184	201,438	--
Soft maple	1,336,456	--	316,821	169,963	137,682	96,729	72,269	311,973	231,019
Ash	1,932,586	--	622,219	485,777	350,381	152,442	142,494	149,489	29,784
Cottonwood and aspen	9,835,056	--	2,963,287	2,671,791	1,916,639	914,826	427,801	745,242	195,470
Basswood	2,590,124	--	489,733	541,373	466,398	376,433	365,966	238,826	111,395
Black walnut	126,703	--	26,152	13,263	52,425	10,139	--	24,724	--
Other eastern soft hardwoods	2,212,465	--	1,056,213	554,244	368,873	79,260	53,614	100,261	--
Other eastern hard hardwoods	11,661	--	--	4,015	7,646	--	--	--	--
Total hardwoods	24,885,053	--	6,842,827	5,675,353	4,433,988	2,543,900	1,724,975	2,776,742	887,269
All species	38,177,803	4,328,877	9,538,385	7,524,139	5,604,742	3,593,149	2,444,982	4,053,269	1,090,262

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates that the volume rounds to less than 1 thousand board feet. Columns and rows may not add to their totals due to rounding.

[1]International 1/4-inch rule.

Table 9. -- All live aboveground tree biomass on timberland by owner category, softwood/hardwood species category, and tree biomass component, Minnesota, 1999 - 2001

(In dry tons)

Owner category and softwood/hardwood category	Tree biomass component							
			Growing-stock trees			Non-growing-stock trees		
	All components	All live 1-5 inch trees	Total	Boles	Stumps, tops, and limbs	Total	Boles	Stumps, tops, and limbs
Public								
Softwoods	74,719,550	15,593,363	57,096,440	43,578,143	13,518,297	2,029,747	1,549,836	479,910
Hardwoods	142,019,323	20,307,837	108,967,380	79,139,261	29,828,118	12,744,107	9,502,095	3,242,011
Total	216,738,873	35,901,200	166,063,820	122,717,404	43,346,415	14,773,853	11,051,932	3,721,921
Private								
Softwoods	30,337,597	4,799,839	24,674,849	19,137,846	5,537,002	862,910	656,179	206,730
Hardwoods	182,293,454	21,012,421	138,574,191	100,499,234	38,074,957	22,706,841	16,806,561	5,900,280
Total	212,631,051	25,812,260	163,249,040	119,637,080	43,611,959	23,569,751	17,462,740	6,107,011
All ownerships								
Softwoods	105,057,147	20,393,202	81,771,289	62,715,989	19,055,299	2,892,656	2,206,016	686,641
Hardwoods	324,312,777	41,320,258	247,541,571	179,638,495	67,903,075	35,450,948	26,308,656	9,142,292
Total	429,369,924	61,713,460	329,312,859	242,354,485	86,958,375	38,343,604	28,514,672	9,828,932

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates the aboveground tree biomass rounds to less than 1 dry ton. Columns and rows may not add to their totals due to rounding.

Table 10.-- Area of forestland in Minnesota effected by damage agents 1994-2001[1]

Minnesota damage agents	2001	2000	1999	1998	1997	1996	1995	1994
				(*In acres*)				
Forest tent caterpillar	7,759,807	2,039,919	495,000	9,000	2,064	--	9,120	--
Large aspen tortrix	--	63,942	340,000	9,000	--	--	--	--
Flooding	17,909	30,697	--	--	--	--	--	--
Spruce budworm	18,893	28,481	70,000	240,242	257,000	207,727	500,100	2,704,000
Oak tatters	2,300	20,000	--	--	--	--	--	--
Frost	--	7,507	--	--	--	--	--	--
Larch casebearer	18,816	6,363	--	--	--	--	--	--
Oak mortality	16,800	6,061	--	--	--	--	--	--
Dutch elm disease	1,052	365	--	--	--	--	--	--
Bark beetles	2,122	100	--	--	--	--	--	--
Winter injury	2,424	--	--	--	--	--	--	--
Wind/Tornado	--	--	465,000	--	--	--	217,800	--
Walking stick	--	--	920	--	--	--	--	--
Oak anthracnose	--	--	150,000	--	--	--	--	--
Aspen defoliator complex	--	--	--	--	--	--	36,600	599,627
Jack pine budworm	--	--	--	--	--	74,836	66,501	6,900
Mortality	47,358	20,571	7,614	5,776	10,308	--	--	--
Total acres effected	7,887,481	2,224,006	1,528,534	264,018	269,372	282,563	830,121	3,310,527

All table cells without observations in the inventory sample are indicated by --.

[1] Aerial survey results 1994-2001

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Results of the combined 1999, 2000, and 2001 annual forest inventories of Minnesota show that 16.3 million acres or 32 percent of the total land area is forested. The estimate of total all live tree volume on forest land is 17.4 billion cubic feet or approximately 1,068 cubic feet per acre. Nearly 15.0 million acres of forest land in Minnesota are classified as timberland (forest land that is not reserved and is of high productivity). The estimate of growing-stock volume on timberland is 14.9 billion cubic feet or approximately 998 cubic feet per acre. All live aboveground tree biomass on timberland is estimated at 429 million dry tons or approximately 28.7 tons per acre. Important pests in Minnesota forests include the forest tent caterpillar, spruce budworm, large aspen tortrix, and introduced larch casebearer.

KEY WORDS: Annual inventory, forest area, forest type, volume, biomass, Minnesota

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